Surface Disposal of Waste Water Treatment Plant Biosludge – an Important Source of Perfluorinated Compound Contamination in the Environment?

A.B. Lindstrom[1], M.J. Strynar[1], L. McMillan[2], D. Knappe[3], E. Arevalo[3], S. Wing[4], A. Lowman[4], M. Serre[4], and P. Jat[4]

1 U.S. Environmental Protection Agency, National Exposure Research Laboratory, Research Triangle Park, NC
2 National Caucus & Center on Black Aged, Inc., Durham, NC
3 North Carolina State University, Department of Civil, Construction, and Environmental Engineering
4 University of North Carolina, Gillings School of Global Public Health

SETAC North America
Vancouver, BC, Canada
November 9-13, 2014

Project Collaborators

Mark Strynar
Sonia Dagnino
Rebecca McMahen
Larry McMillan
Erik Andersen
Shuang Liang
Andy Lindstrom

Elaine Chiosso

Detlef Knappe
Elisa Arévalo
Jeremy Fireline

Ryan Heise

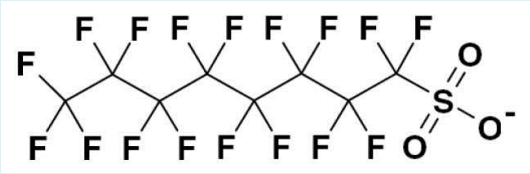
Steve Wing
Amy Loman
Jill Johnson
Marc Serre
Prahlad Jat

Joe Weitzel
Carol Ball

Rob Hale
Mark La Guardia

Presentation Outline

Discuss perfluorinated compounds (PFCs), their properties, toxicity, and how they get into sewage sludge



Sewage sludge, regulations and concerns, applications in NC

Research showing that sewage sludge from specific waste water treatment plants in NC contains high levels of PFCs. Use of sludge as a low cost fertilizer leads to contamination of fields and surface water

Implications regarding the use of sewage sludge

Sources of PFC exposure in humans

Best documented source includes contaminated drinking water around industrial operations e.g., Cottage Grove, Minnesota; Parkersburg, West Virginia; Dalton, Georgia; Decatur, Alabama; Arnsberg, Germany; Osaka, Japan

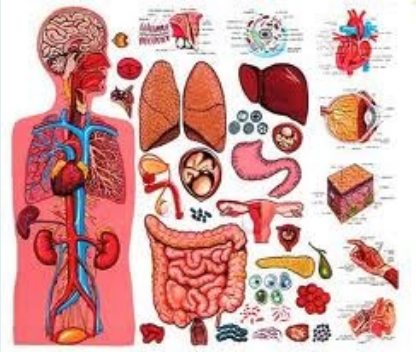
Food is also implicated in many studies (mostly modeling), but there are few good data on food items (complex matrices). Exception is fish, which is a well documented source.

Health Effects Summary

Animal toxicity
- Causes liver, immune system, developmental, endocrine, metabolic, and neurobehavioral toxicity.
- PFOA and PFOS caused tumors in chronic rat studies.

Human health effects associated with PFC(s) in the general population and/or communities with contaminated drinking water include:

- ↑ cholesterol
- ↑ uric acid
- ↑ liver enzymes
- ↓ birth weight
- ↓ vaccine response
- Thyroid disease
- Osteoarthritis
- Diabetes
- Testicular and kidney cancer
- Pregnancy-induced hypertension
- Ulcerative colitis
- Effects in young adulthood from prenatal exposures
  - *Obesity in young women.*
  - *↓ sperm count in young men.*



US Environmental Protection Agency
Provisional Health Advisories

Provisional Health Advisory levels for PFOS and PFOA in drinking water

PFOS = 200 ng/L PFOA = 400 ng/L

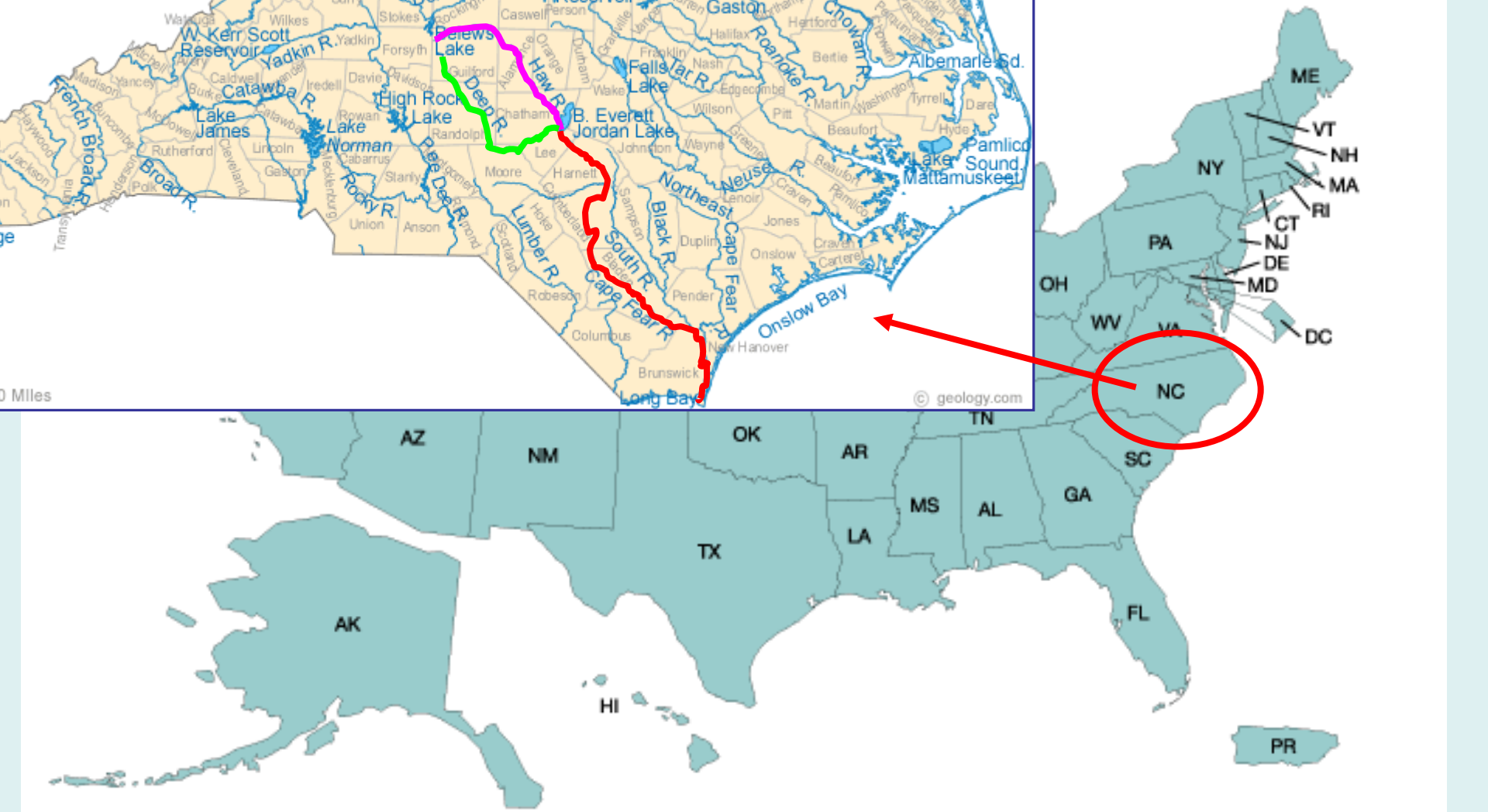
Short term exposure only – no long term (chronic) standard set

* Some experts calling for reduction in standards by a factor of 100 – 1000 to be truly protective for long term exposures

PFOS = 2 ng/L PFOA = 4 ng/L

* Immunotoxicity of perfluorinated alkylates: calculation of benchmark doses based on serum concentrations in children Grandjean, P ; Budtz-Jorgensen, E ;Environmental Health (12:35) DOI: 10.1186/1476-069X-12-35, APR 19 2013

The Cape Fear River Basin



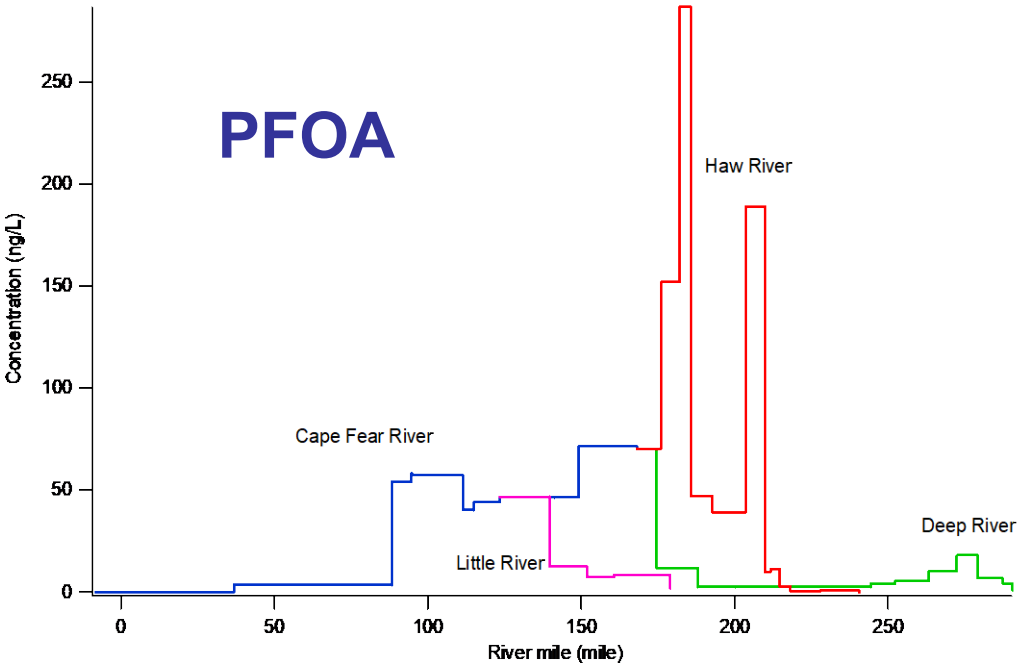
Survey of perfluorinated compounds in surface water 2006

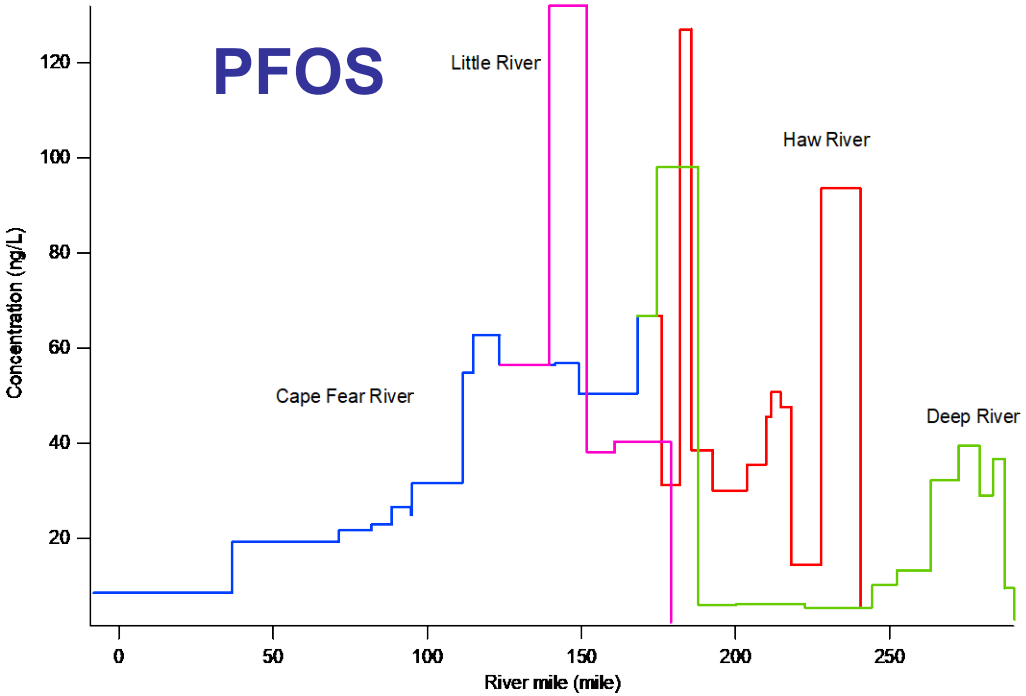
SS Kemmerer sampler

Lab-made dip sampler

Collection of surface water from a bridge crossing

PFC profiles in the Cape Fear Drainage Basin, North Carolina, USA





Nakayama *et al.* *Environ. Sci. Technol.* **2007,** 41: 5271-5276

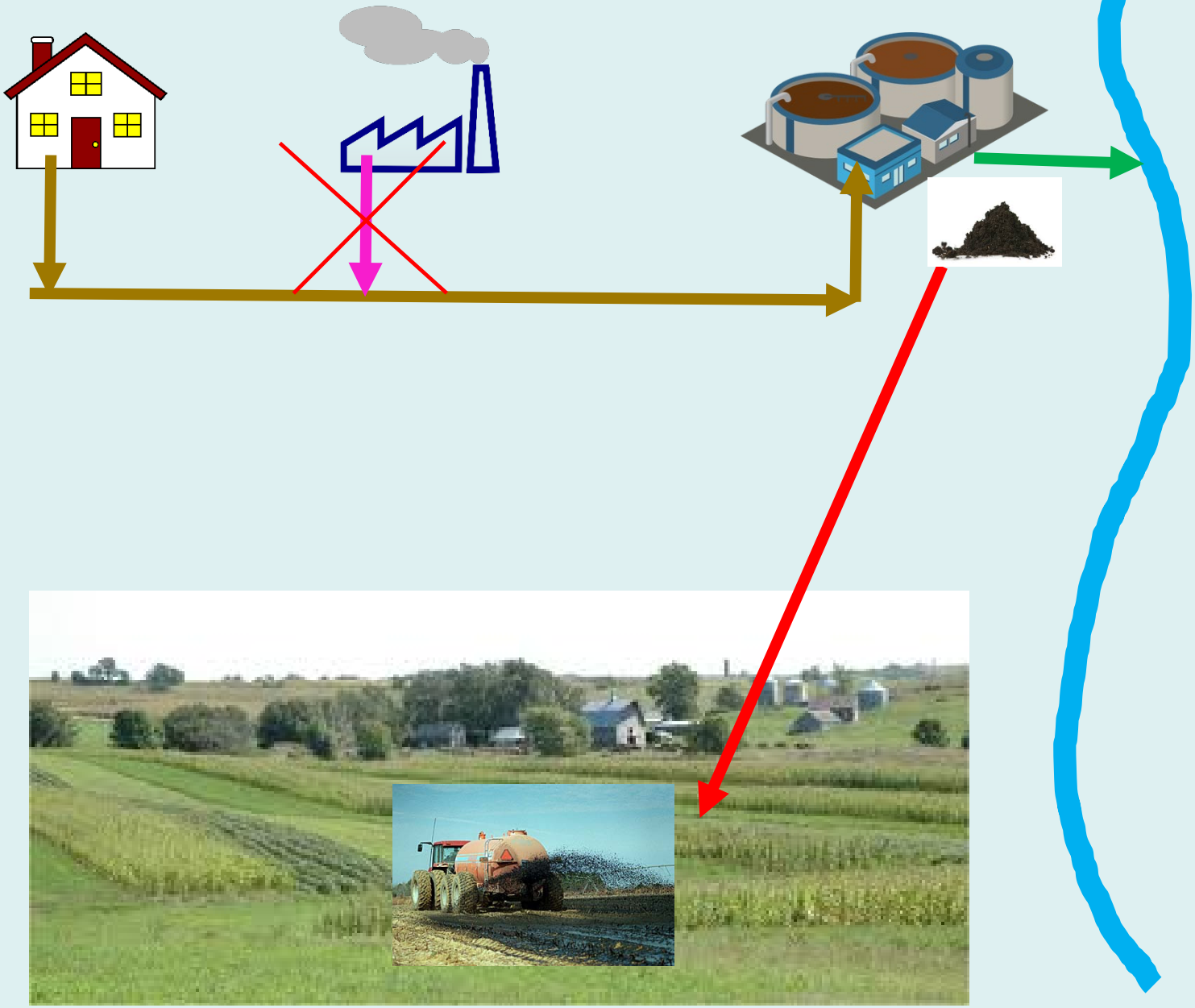
Project Questions

- Why would PFC concentrations be high and variable in North Carolina? Why is surface water contamination important?

- Any evidence to suggest that using WWTP biosolids as fertilizer leads to elevated PFCs concentrations in North Carolina?

- What are the impacts on communities?

- What are the implications for groundwater and drinking water, livestock, produce, fisheries, etc.?



Back to the Future: March 2009, *Environmental Science & Technology*

Environmental News

EPA finds record PFOS, PFOA levels in Alabama grazing fields

Because of very high levels of perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and other perfluorochemicals found in agricultural soils near Decatur, Ala., scientists with the U.S. EPA, the U.S. Department of Agriculture (USDA), and the U.S. Food and Drug Administration (FDA) are investigating whether perfluorinated chemicals have entered the human food chain and contaminated meat.

The source of PFOA and PFOS, both of which occur at low part-per-million levels, is treated municipal sewage sludge, or biosolids, that were applied to some 5000 acres of agricultural land, according to Gail Mitchell, EPA Region 4's deputy director of water management. EPA is still investigating how the chemicals got into the sludge, adds Cathy Fehrenbacher, chief of EPA's exposure assessment branch, which is tasked with investigating the fate and transfor grazing beef cattle for 12 years, according to Mitchell.

If the chemicals are found to have contaminated meat, the results would mark the first time that perfluorochemicals have been traced from sludge to commercially produced food. In 2006, perfluorochemical contamination of two German rivers was traced to fields treated with sludge (*Environ. Sci. Technol.*

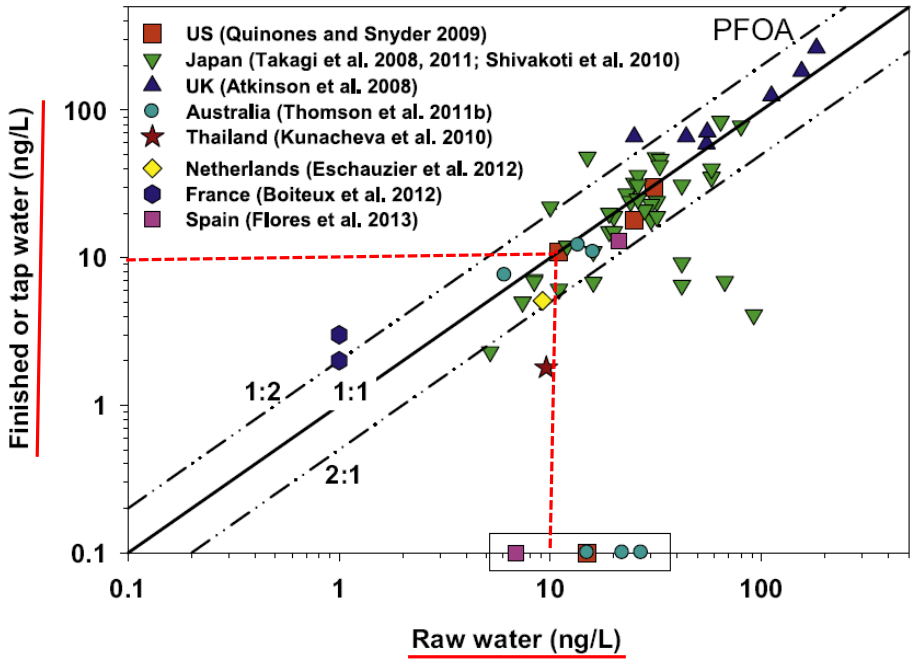
USDA AGRICULTURAL RESEARCH SERVICE

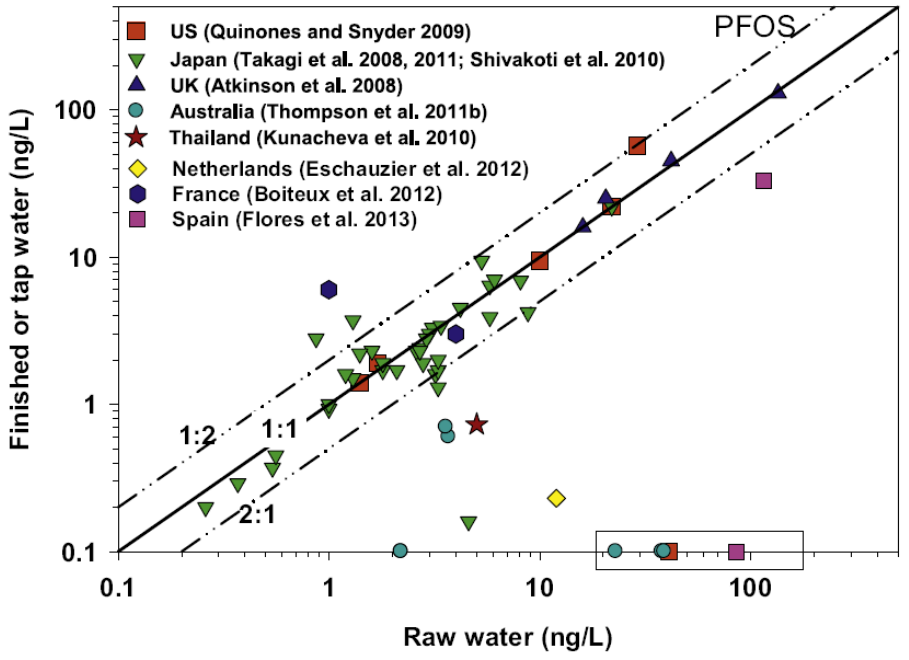
Cattle may have picked up PFOA from sludge that was spread on fields where they graze.

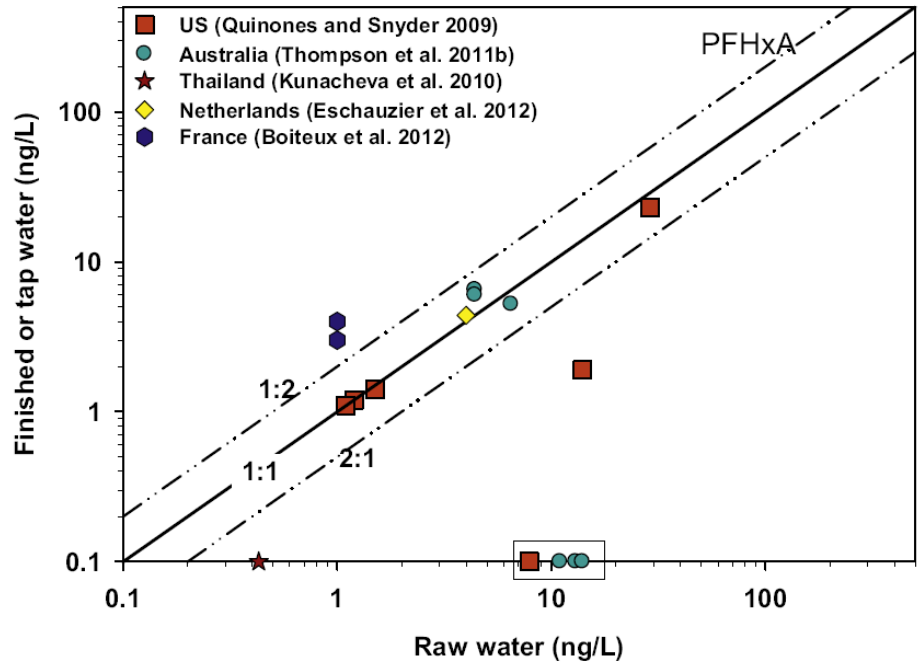
sampling private drinking-water wells located much closer to the fields. These wells serve fewer than 100 people, Mitchell estimates.

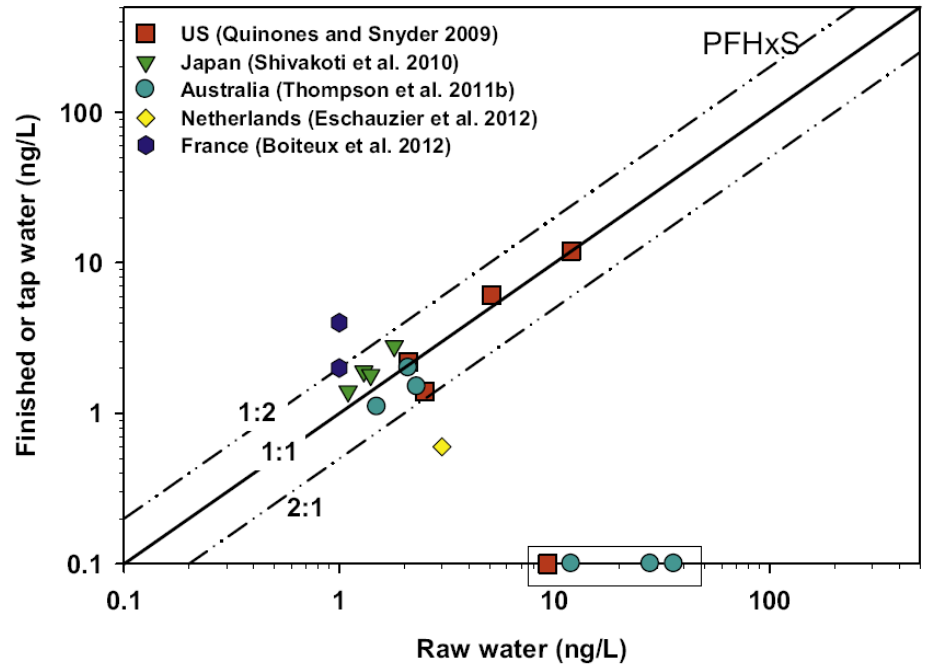
EPA officials notified both USDA and FDA about the high levels of perfluorinated chemicals because the land was used for grazing cattle, Mitchell says. USDA is responsible for inspecting raw meat such as beef or chicken for potential contamination, and FDA oversees processed foods. But neither USDA nor FDA has analyzed any samples.

The high concentrations of perfluorochemicals in the Decatursludge could be a rare situation, or a common one—published data on the concentrations of perfluorinated chemicals in sludge are minimal, and almost nothing is known about concentrations in soils, says Christopher Higgins of the Colorado School of Mines. "Based on published reports, the levels in the soil are high compared



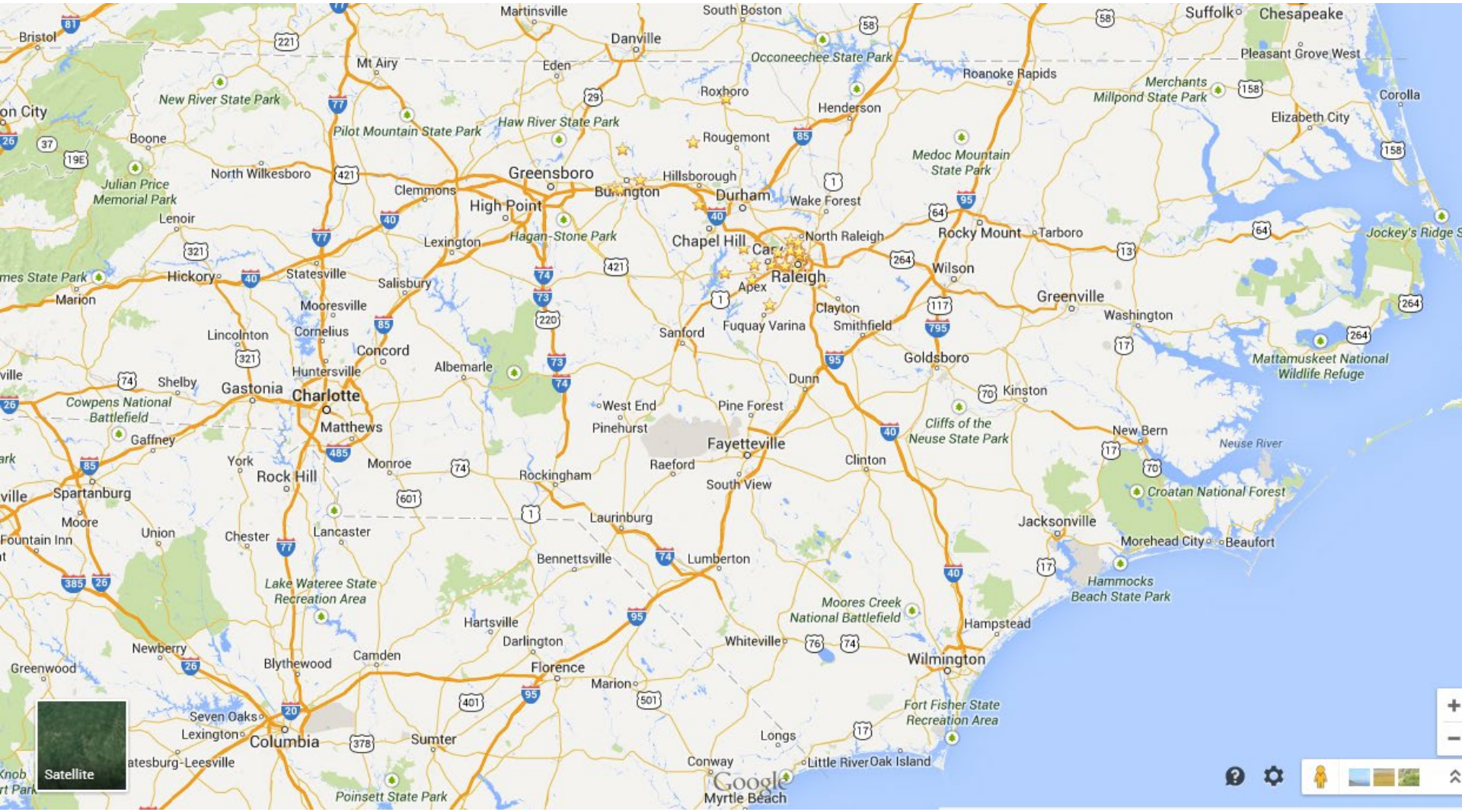




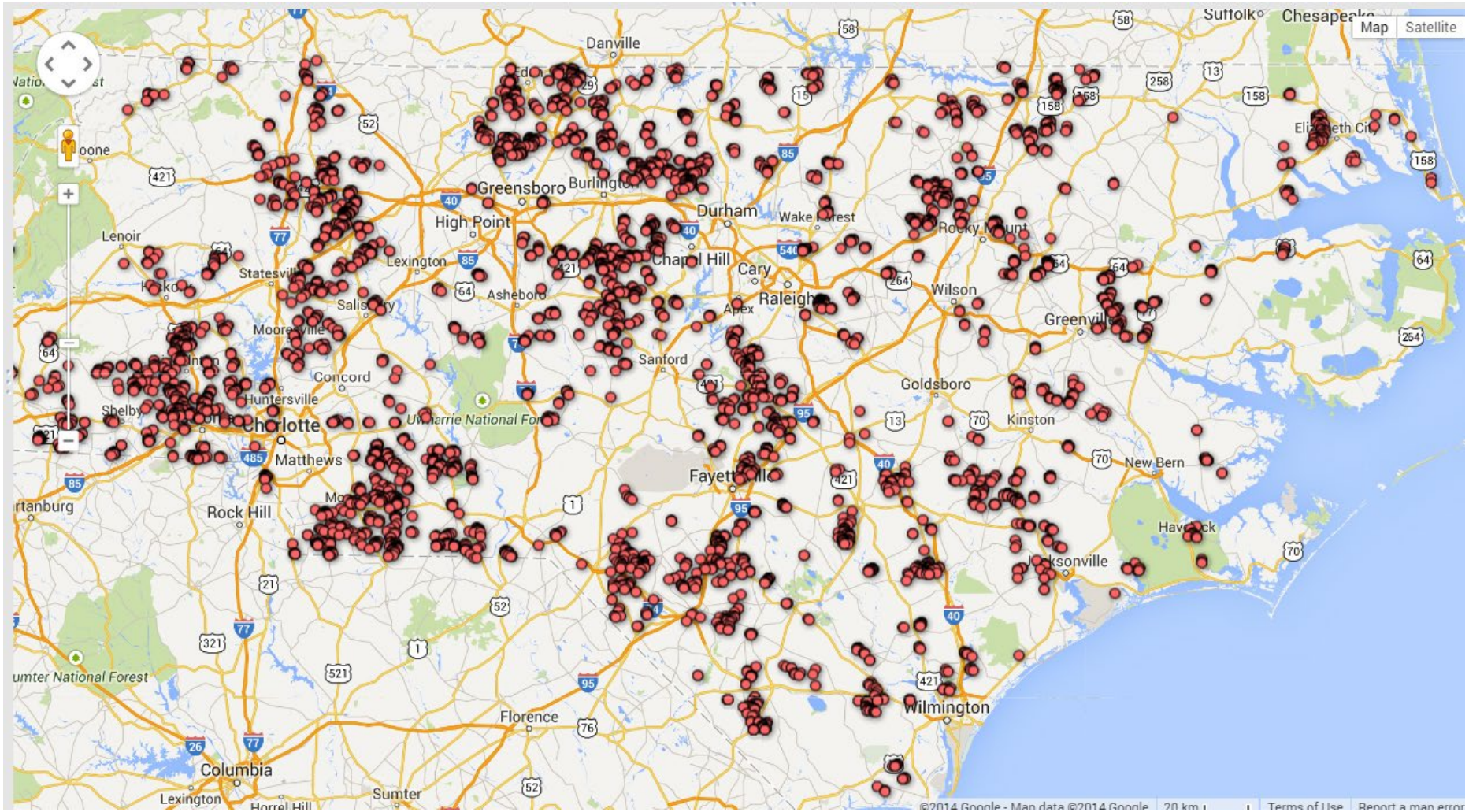


Rahman et al., (2014) *Water Research,* 50:318-340

Permitted land application sites in North Carolina



5,258 Permitted sludge application sites in North Carolina



What are “Biosolids”?

- “Biosolids” are what remains after WWTP processing

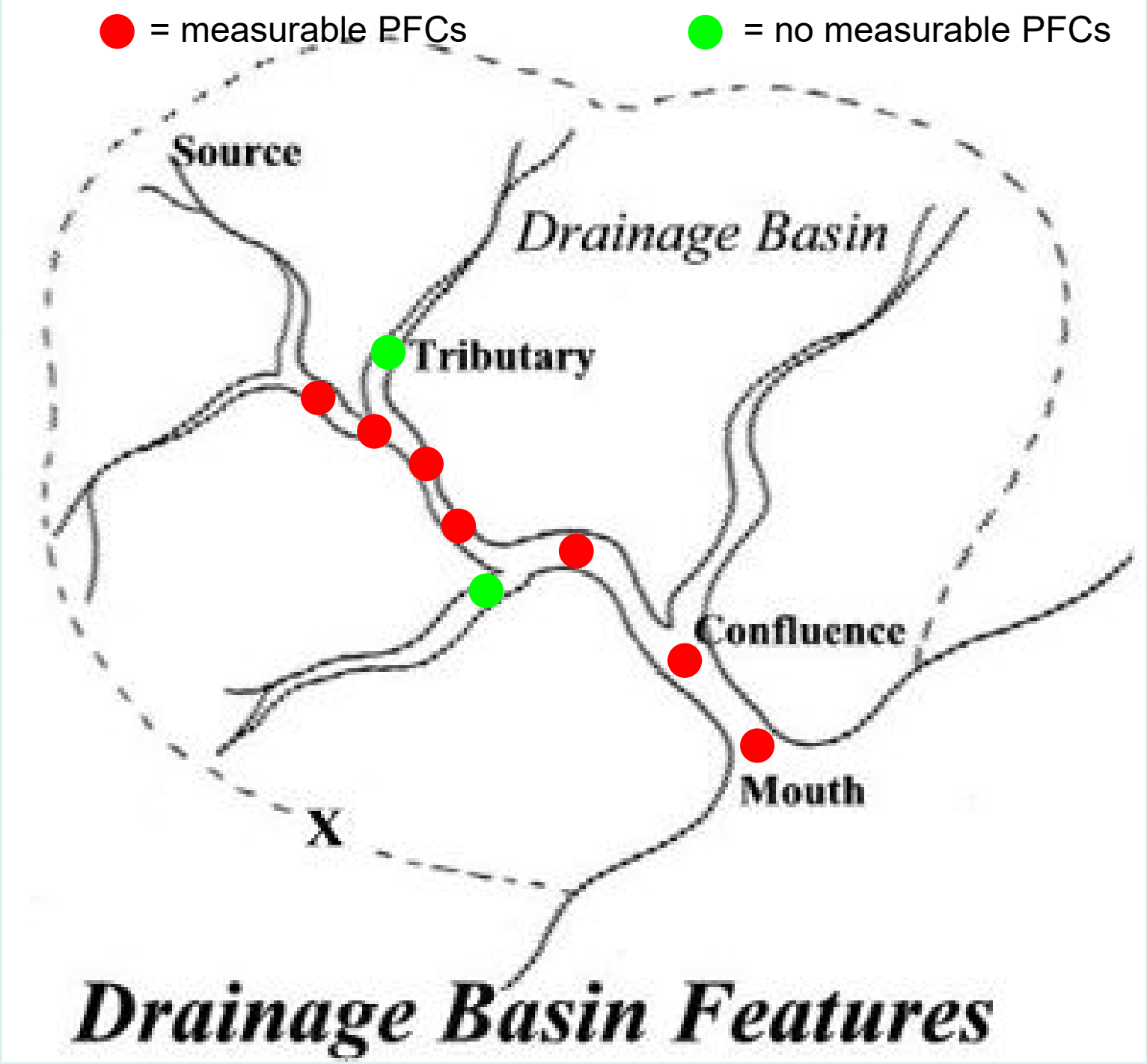
Sewage sludge probably a more accurate term

- Could contain anything that comes down the pipe to the WWTP, varies greatly depending on community type, industry effluents, plant design and operation

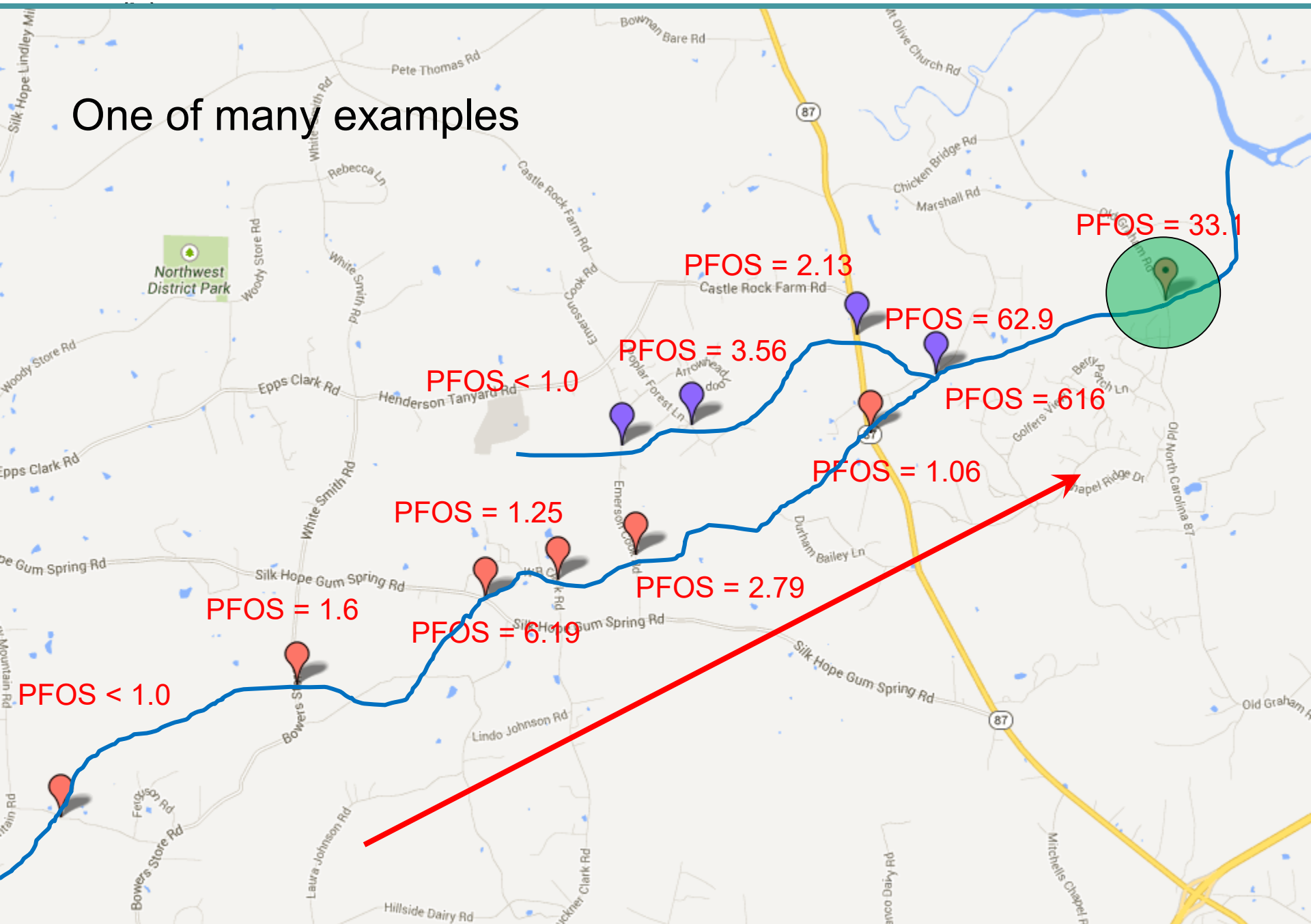
- 503 regulations cover pathogens, nutrients, and metals but NOT persistent organic pollutants (e.g., perfluorinated compounds, flame retardants, pharma compounds, plasticizers…)

~ 50% of the “biosolids” generated in the US are land applied as fertilizer

Is this practice responsible for the distribution of persistent organic pollutants in the environment?


= measurable PFCs
= no measurable PFCs
Source
Drainage Basin
Tributary
Confluence
Mouth
X
Drainage Basin Features

Dry Creek Sub-basin (Initial recon results PFOS 154 ng/L PFOA 102)

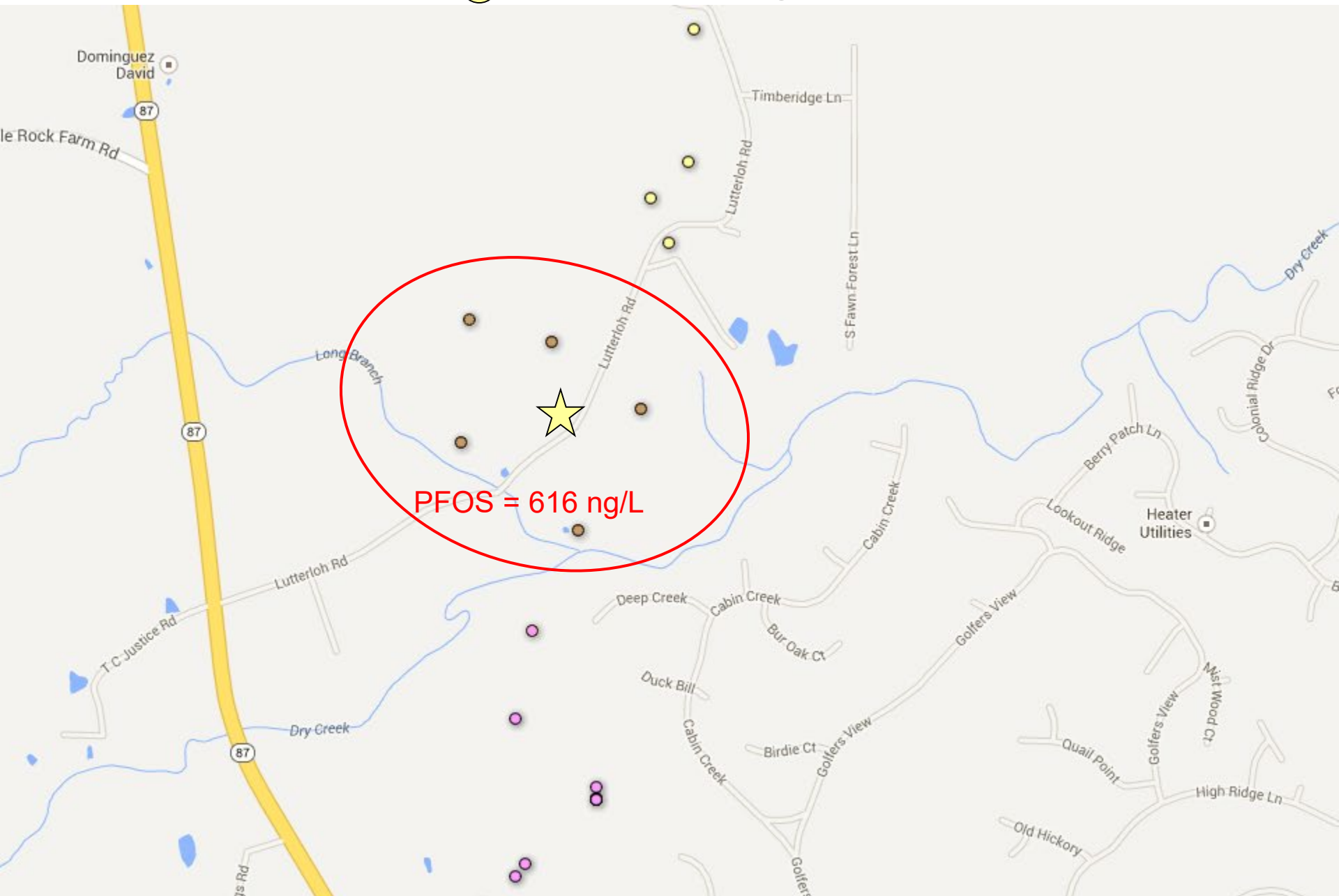



PFOS = 616 ng/L

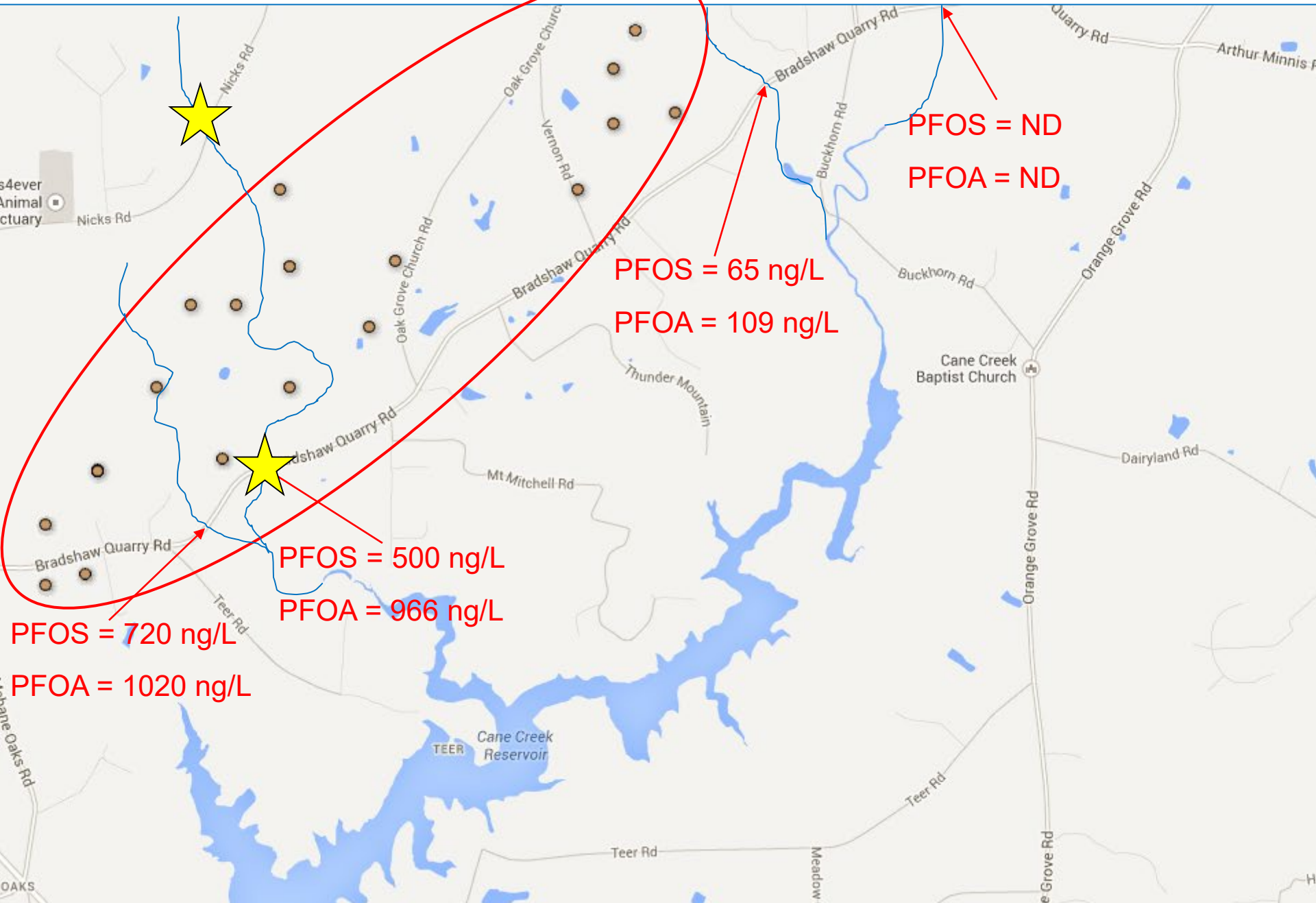

NO TRESPASSING
BIOSOLIDS APPLICATION AREA
PERMIT #WQ0000520
CITY OF BURLINGTON
FOR MORE INFO CALL (336) 675-5927

Permitted Sludge Application Sites in the Dry Creek Subbasin

= Municipal Utilities, = family residence, = reclaimed water



Cane Creek Resevoir - Serving Orange County




Burlington, NC
WWTP Biosolids

Analysis of PFCs in local WWTP Sewage Sludge Supernatants (ng/L)

	South sludge 8/1	South sludge 8/1	East sludge 8/1	East sludge 8/1	South sludge 8/23	South sludge 8/23	East sludge 8/23	East sludge 8/23
C6	157	141	1080	1130	308	300	1280	1340
C7	210	191	880	883	384	446	1080	1300
PFHxS	203	214	734	738	478	459	1050	1010
PFBS	234	252	409	417	375	331	767	766
PFOA	179	177	648	705	535	565	1120	1130
C9	176	144	989	962	659	612	1170	1450
PFOS	284	216	1410	1300	1420	1170	1570	1680
C10	437	346	1830	1560	1810	1500	2180	2090
C5	100	100	159	167	72	64	331	289
C4	< 0	< 0	< 0	< 0	< 0	< 0	< 0	< 0

Most compounds in the range 100s to 1000s ng/L in sludge supernatants applied to fields

Sewage sludge from these WWTPs is ~ 5% solid and 95% liquid supernatant

If PFOS has not been produced in the US in over a decade, why is it still present in sewage sludge?

Implications and Questions

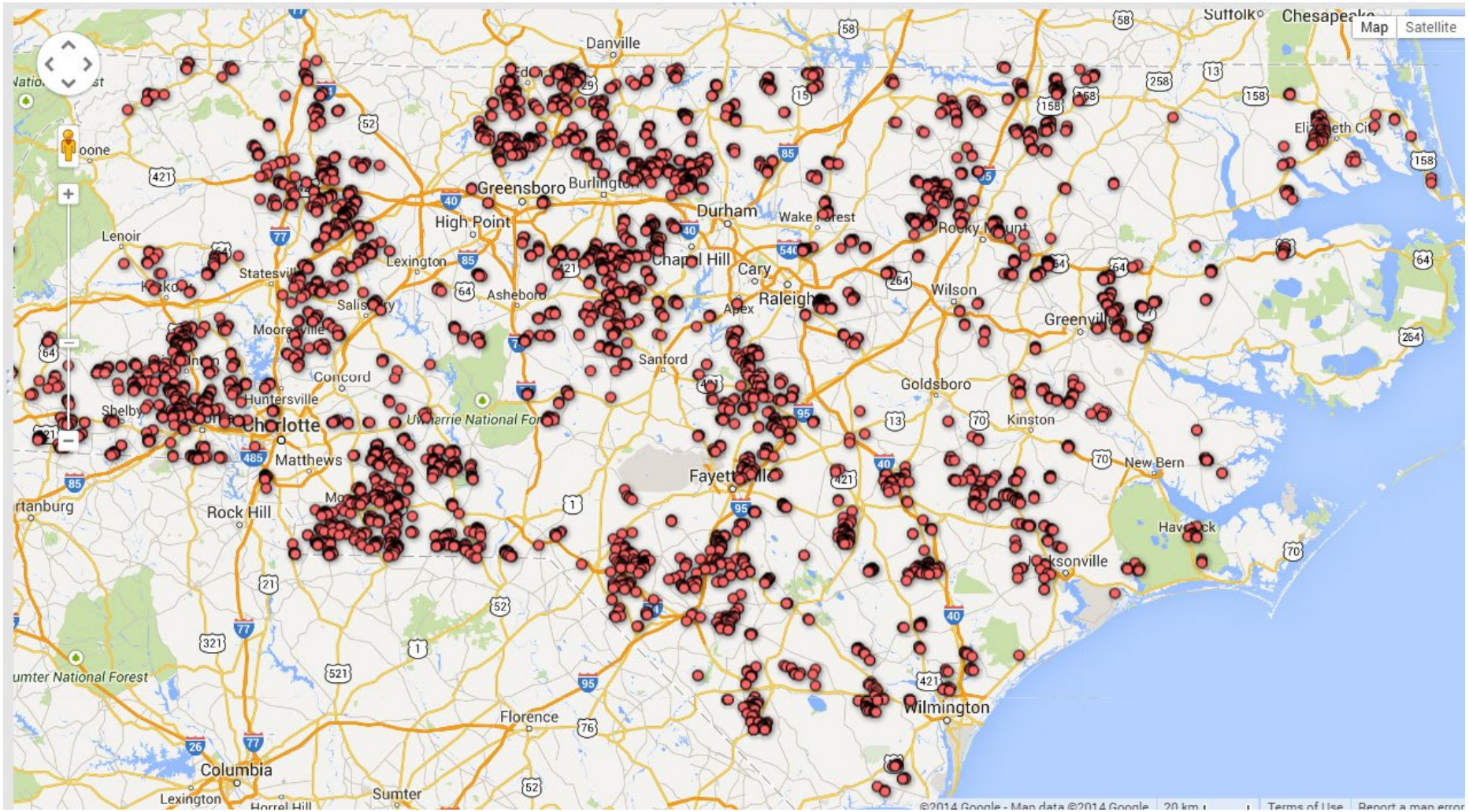
- Perfluorinated compounds at high concentrations in sludges, on fields, in surface water in areas receiving sludge applications

- PFOS, PFOA, and related compounds still in use (or still in the system) despite regulations and restrictions

- sludge regulations only require testing for pathogens, 9 metals and nutrients - other persistent pollutants are not measured

- Surface application of these wastes can lead to contamination of ground and surface water, agricultural crops and livestock, and the people living in these communities

5,258 Permitted sludge application sites in North Carolina



Questions?

Email: lindstrom.andrew@epa.gov